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Memomath: Educational Game Application for Elementary School Children in Special Inclusion Classes for Students with Slow Learner Diagnosis

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ABSTRACT

Memomath is a game-based educational application designed to support the learning of children diagnosed as slow learners in elementary school inclusion classes. This application integrates mnemonic-based math, reading, and memory exercises to improve students' academic skills and learning motivation. This research was conducted at SDIT Madani Islam Terpadu Kota Payakumbuh, an inclusive school that provides special programs for students with slow learning needs. The waterfall method was applied in the development of this application, involving the stages of needs analysis, design, implementation, testing, and maintenance. The test results showed that this application was effective in increasing engagement and understanding of concepts in students, especially at the age of 7-12 years. The data also revealed the relationship between age and duration of application use, providing important insights for design optimization. This study shows that a targeted gamification approach can make a significant contribution to the education of children with special needs, especially in helping them overcome learning challenges.

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1. Introduction

Memomath is an educational game designed to meet the educational needs of elementary school children with slow learning abilities. This game combines math, reading, and memory-building exercises to create a comprehensive learning experience for students in inclusive classes[1][2]. Memomath is built with the Construct 3 platform with the basic features of the game emphasizing memorization skills where students are required to do each game challenge until they get the correct answer. The game concept combines mnemonics, which are memory aids that utilize interactive UI/UX concepts aimed at increasing engagement and improving learning outcomes for inclusive class students so that they can develop student motivation to be involved in learning.

Educational games such as mobile application-based games have helped in the development of cognitive, social, and emotional behaviors in children with special needs[3]. With this underserved population[4][5]. Through the integration of multisensory activities and a focus on individualized instruction

and efforts to encourage academic progress and build self-confidence in students diagnosed with learning disabilities [6][2]. The game mechanics and content are carefully crafted to address the unique learning needs of children with special needs, with an emphasis on those diagnosed with learning disabilities[7][3][8]. The development of game applications follows a rigorous process involving the collaboration of educational experts, game designers, and representatives of the target population[9].

Extensive research was conducted to understand the specific challenges faced by children with slow learning, including difficulties in remembering information, processing speed, and attention span. Based on this research, the Memomath team collaborated with the Madani Integrated Islamic Elementary School in Payakumbuh City as a trial site for the development of the application.

SDIT Madani Islam Terpadu is a child-friendly school and has an inclusive program for children with disabilities supervised by school psychologists and professional therapists. SDIT Madani Islam Terpadu also has individual classes, namely classes that contain children with special needs such as autism, down syndrome, ADD, ADHD, Slow Learner, and others. This study focuses on children diagnosed with Slow Learner. Children with this diagnosis have an IQ with an evaluation value range of 70 - 85.

Research on educational game design shows that this approach is effective in improving student learning through interactive and enjoyable experiences. Munir (2017) explains that digital learning media, including educational games, can increase student motivation in understanding the material [10]. Hwang et al. (2012) proved that problem-based games can improve student performance in web-based learning activities [11]. Another study conducted by Kiili in 2005 emphasized that educational games designed with a problem-based learning approach can develop students' problem-solving abilities [12]. Another study by Gunawan and Istiono (2024) found that game-based augmented reality applications for children with Down syndrome can improve cognitive skills in color recognition [13]. In addition, Suryadana and Deli (2024) showed that visual novel games can increase students' interest in learning through interactive storytelling [14]. In the context of special needs, Nugroho and Sari (2021) emphasized the importance of gamification in Construct-based learning applications to help students with various learning styles [15]. These results suggest that educational games have great potential in supporting student learning through engaging and effective experiences.

2. Research Method

2.1. Research Stages

This research was compiled by first creating a structured research framework. This is needed so that the research conducted becomes more focused[16]. This framework contains the stages of research that the author conducted as in Figure 1 below:

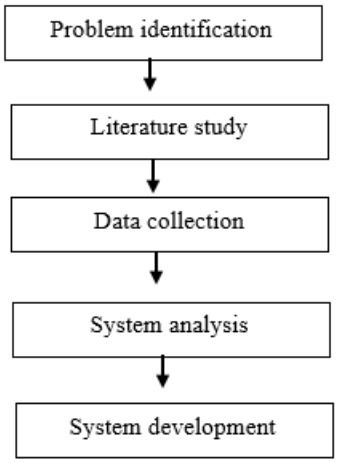

Figure 1. Research Stages

Based on the research stages in Figure 1, the discussion at each stage can be described as follows:

a. Problem identification

At this stage, direct observation was conducted on the research object, namely SDIT Madani Islam Terpadu Kota Payakumbuh. From the results of observations with the team, problems were found faced by the school, namely the existence of several special classes for children with slow learning. The main obstacles identified include difficulty in remembering

information, slow processing speed, and limited attention span. Based on this problem, the author attempts to develop an application that is designed in an attractive way to help students overcome these problems.

b. Literature study
After the problem is identified, the next stage is to conduct a literature study from various sources, such as books, the internet, journals, and others. This literature study aims to find a theoretical basis that is relevant to the research theme, so that it can strengthen the basis for developing the proposed solution.

c. Data collection
At this stage, data collection is carried out through observation and interview methods. The observation method is used to understand the actual conditions in the field, while interviews are conducted with related parties, such as teachers and therapists at school. This process aims to explore the specific needs of students and find solutions that are appropriate to the problems faced.

d. System analysis
This stage aims to understand the needs of the system to be developed. System analysis is an important step to ensure that system needs and specifications can be clearly understood. This process includes data collection, problem identification, and determining the right solution so that the system can meet user expectations. In addition, system analysis also helps define the scope of the project, identify potential risks, and provide a strong basis for the design stage. The results of this analysis are the main reference in the system development process so that its quality and effectiveness can be guaranteed.

e. System development
The final stage is system development, which begins after the system analysis is completed. At this stage, the design that has been designed is implemented into a real system, either in the form of software, hardware, or a combination of both. The development process includes coding or programming, game testing, and integration of system components to ensure that all functions run according to predetermined needs. In addition, the system is also tested to ensure its reliability, security, and scalability. The documentation process is carried out to provide technical guidance for subsequent developers or users. This stage is considered complete after the system has been thoroughly tested and is ready to be implemented in an operational environment[17].

2.2. Data Collection Method

This study required accurate data to be a solution to the problems in the research object. Data were collected through interview and observation methods [18]. Interviews were conducted to obtain in-depth information from related parties, such as sources or experts, in order to gain a clearer understanding of the problems being studied [19]. The sources in data collection were teachers of SDIT Madani Islam Terpadu, especially those who teach inclusive classes. Meanwhile, the observation method allows researchers to directly observe the conditions and processes that occur in the field, so that the data obtained is objective and in accordance with the existing facts. The use of these two methods aims to ensure the accuracy of the data that will be the basis for the analysis and decision-making process in this study.

2.3. System Development Methods

System development is an important step in the process of designing a system to ensure results that are in accordance with the needs and objectives that have been determined. The system development method used in this study is the waterfall method or linear sequential. This method is often called the waterfall model because the development process is carried out sequentially, like the flow of water flowing from one stage to the next. Each stage in the waterfall model, from needs analysis, system design, implementation, testing, to maintenance, must be completed before proceeding to the next stage. This approach ensures that each step is carried out in a structured and systematic manner, thus minimizing the risk of errors in subsequent stages. Thus, this method is very suitable for projects with clear needs and do not change significantly during the development process. Figure 2 is a picture of the waterfall model used in this study.

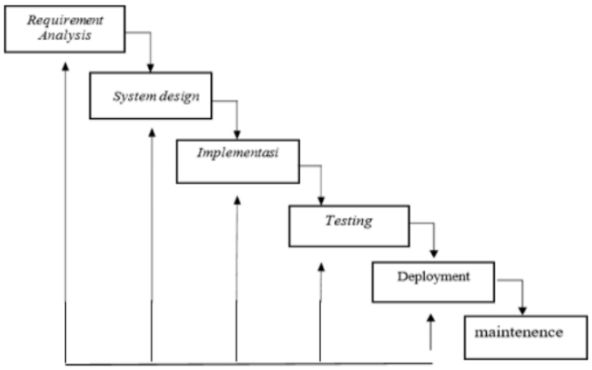

Figure 2. Waterfall Model

The explanation of each stage of the waterfall model is as follows:

a. System requirements (requirement Analysis)
At this stage, system requirements are analyzed in depth to understand what is needed by users or stakeholders. Information is collected through interviews, observations, or documentation studies. The result of this stage is a detailed system requirements specification and becomes a reference for the next stage.

b. System desain
This stage aims to design the structure and architecture of the system based on the specifications that have been determined. The design includes designing the user interface, database structure, and system process flow. The result is a blueprint or technical design that serves as a guide for the implementation stage.

c. Implementation
In the implementation phase, the system design that has been created is converted into program code or hardware that is ready to use. This process involves programming activities, device configuration, and integration of system components.

d. Testing
This stage is carried out to ensure that the developed system is error-free and meets user needs. Testing includes functional testing, integration testing, performance testing, and security testing[20]. The result is a system that is guaranteed to be of high quality before being implemented.

e. Deployment
At this stage, the system that has been tested is applied to the operational environment. This process includes installation, configuration, and user training. The system begins to be used to support operational activities in accordance with development objectives.

g. Maintenance
This stage is carried out to ensure that the system continues to run well after being implemented. Maintenance includes fixing bugs if found, improving features as needed, and monitoring the system to ensure it remains reliable in the long term. Maintenance is an ongoing stage that is important to ensure the sustainability of the system.

3. Results and Discussion

3.1 Game Desain

This educational game applies the Mechanics, Dynamics, and Aesthetics (MDA) framework introduced by Hunicke, LeBlanc, and Zubek (2004) as a guide in designing and understanding games from the perspective of developers and users. Educational games are games specifically designed to teach users a certain learning, concept development and train their abilities[21][22]. This framework consists of three main elements: Mechanics, Dynamics, and Aesthetics. From a mechanics perspective, developers can design game components to create a certain experience for players. Meanwhile, through aesthetics, users experience the

dynamics of the game that allows them to understand and evaluate the relationship between mechanics and dynamics. The MDA framework provides a systematic approach to creating games that are not only technically functional but also provide an interesting experience for players.

3.1.1. Platform Desain:

This game is designed for the Android mobile platform with handheld devices[23]. Based on interviews with five teachers and 3 therapists, 60% stated that children with slow learners prefer touchscreen devices. This also reveals that handheld devices are effective in increasing student engagement in the learning process in the age range of 7-12 years.

3.1.2 Concept and Material

This game educates the classroom learning process both in memorizing, introducing mathematics, understanding the concept of a healthy diet and character building. This educational and simulation game aims to improve the understanding of learning mechanisms in slow learners without causing frustration.

3.1.3 Character

The main character was chosen through a survey of Madani Elementary School students in Payakumbuh City, who preferred human characters over animals/plants or robots. Based on this interest, the character was chosen
star_border

3.1.4. Interface

The interface is designed to be simple and consistent, in accordance with the curriculum designed by Madani Integrated Islamic Elementary School in Payakumbuh City for special needs children inclusion classes. Other recommendations include the use of minimal buttons to avoid cognitive overload.

3.2. Interface Desain

The Game Engine used is a software framework specifically designed for the creation and development of video games. As a software system, the game engine provides various core functions needed in game creation, from graphic rendering, mathematical simulation, to memory management. The game engine is a basic foundation that allows developers to create games more efficiently and effectively.

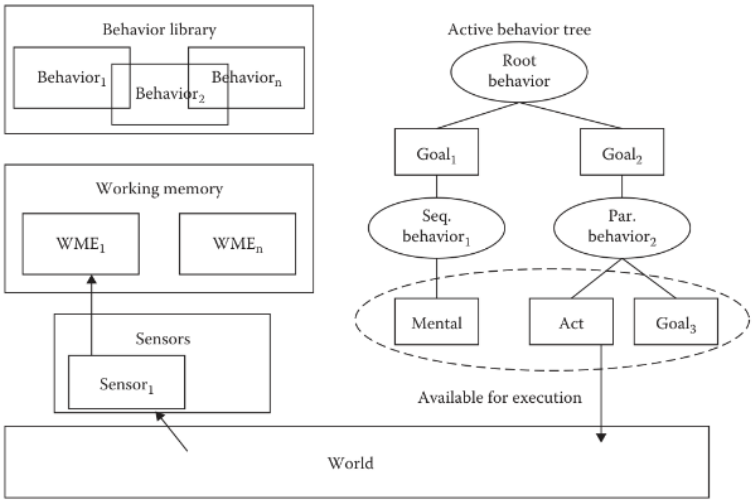

Figure 3. Story dan Game Structures with indirect control

Memomath uses Construct 3 as its HTML5-based Game Engine developed by Scirra Ltd. It is aimed primarily at non-programmers, allowing rapid game creation through visual programming. It was first released as a GPL-licensed DirectX 9 game engine for Microsoft Windows with Python programming[24]. The primary method of programming games and applications in Construct 3[25] is through the 'event sheet', which is the main element used to organize the game's logic and behavior. The Event Sheet acts as a visual script, allowing users to create and manage logic without having to manually write code[26].

The following is the Memomath interface page:

1. Opening Page

Figure 2. Memomath home page

The home page is the main screen that appears after users open the application. It serves as the central hub for navigation and access to key features. This image is usually included to provide readers or users with a visual representation of what the home page of the Memomath application looks like. It helps reinforce the textual description in the document.

Figure 3. Level selection menu page

The game's home page displays characters that are the characters that appear in each level of the game. The total game levels in Memomath consist of 4 levels and each level has a different level of difficulty.

2. Level 1 page

Figure 4. Level 1 interface

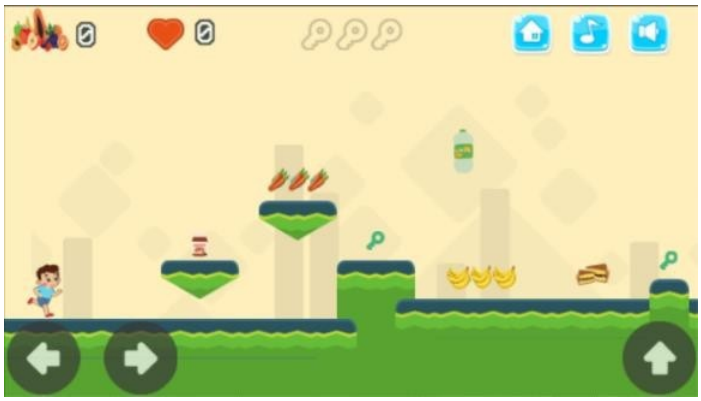

Figure 5. Game interface level 1

Level 1 in Memomath is a platformer type game which is the initial level to introduce respondents to the CFSFGF diet (Casein Free, Sugar Free, Gluten Free). At this level, respondents are required to choose the right type of food in order to get a high score to advance to the next level.

3. Level 2 page

Figure 6. Initial interface level 2

This is the first screen or interface that appears when a user enters Level 2. It often sets the tone for the level and may include instructions, objectives, or visual elements related to that level's theme.

Figure 7. Game interface level 2

Level 2 on Memomath is a word memorize type game which is a game level to help respondents remember everyday object words. Starting from fruits, animals and objects found in the house. At this level, respondents are also required to repeat the words that have been arranged by helping to spell by Memomath.

4. Level 3 page

Figure 8. Initial interface level 3

Figure 8. Initial Interface Level 3 refers to an image or illustration showing the first screen or interface of Level 3 in the application or game. This screen appears when users enter or start the third level of the app, providing the initial setup for that level. This is the screen that appears when a user begins Level 3. It typically introduces new challenges or tasks that are specific to that level and helps guide the user through the experience.

Figure 9. Game interface level 3

Level 3 on Memomath is a simple math learning game starting from the concept of multiplication, addition and subtraction which is a game level to help respondents in working on simple math problems. At this level, respondents are assisted with directions from the level character in solving simple addition problems until they successfully choose the correct answer.

5. Level 4 page

Figure 10. Initial interface level 4

Figure 11. Game interface level 4

Level 4 in Memomath is a game to develop independence skills. At this level, respondents are directed to arrange objects found in the house and place them in the correct position according to the game's instructions. The overall duration of the game in Memomath requires an average of 20-45 minutes per person, and each respondent has a different time for each level completion in Memomath.

3.3. Testing Level

The clustering results of the two datasets, namely the relationship between age and adaptability and age and duration of application use, show that younger children tend to have lower levels of adaptability and are grouped in certain clusters. This indicates that they need more guidance or instruction in using educational applications. In contrast, older children with high adaptability are grouped in different clusters, reflecting their ability to be more independent in understanding and using applications. This graph provides insight into how age and adaptability contribute to children's learning experiences.

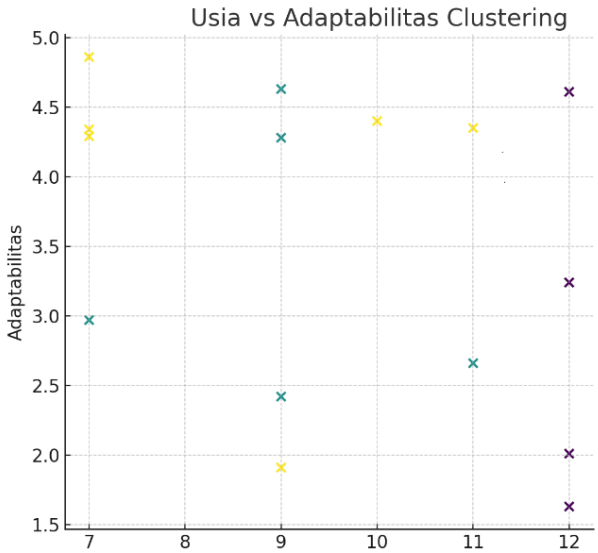

Figure 12. Graph of Age and adaptability of respondents to the Memomath game

The graph in Figure 12 shows the relationship between age and duration of app usage. Younger children tend to be in the cluster with shorter usage duration, possibly due to attention constraints or difficulty understanding content. On the other hand, children with longer usage duration may indicate higher engagement or the need for additional time to complete tasks. This graph helps identify app usage patterns based on age and usage duration, which can be used to optimize app design to be more engaging and effective for all age groups. This analysis provides a basis for decision-making in improving children's learning experiences.

6. Conclusion

Designed games can help in delivering learning materials through interesting applications. Based on the analysis of application usage patterns measured by age and duration of use, it shows that age affects

children's engagement in the application. Younger children tend to use the application for a shorter duration, while children with longer usage duration show higher engagement. These results provide insight into optimizing application design to be more interesting and effective, and become the basis for decision making in improving children's learning experiences.

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